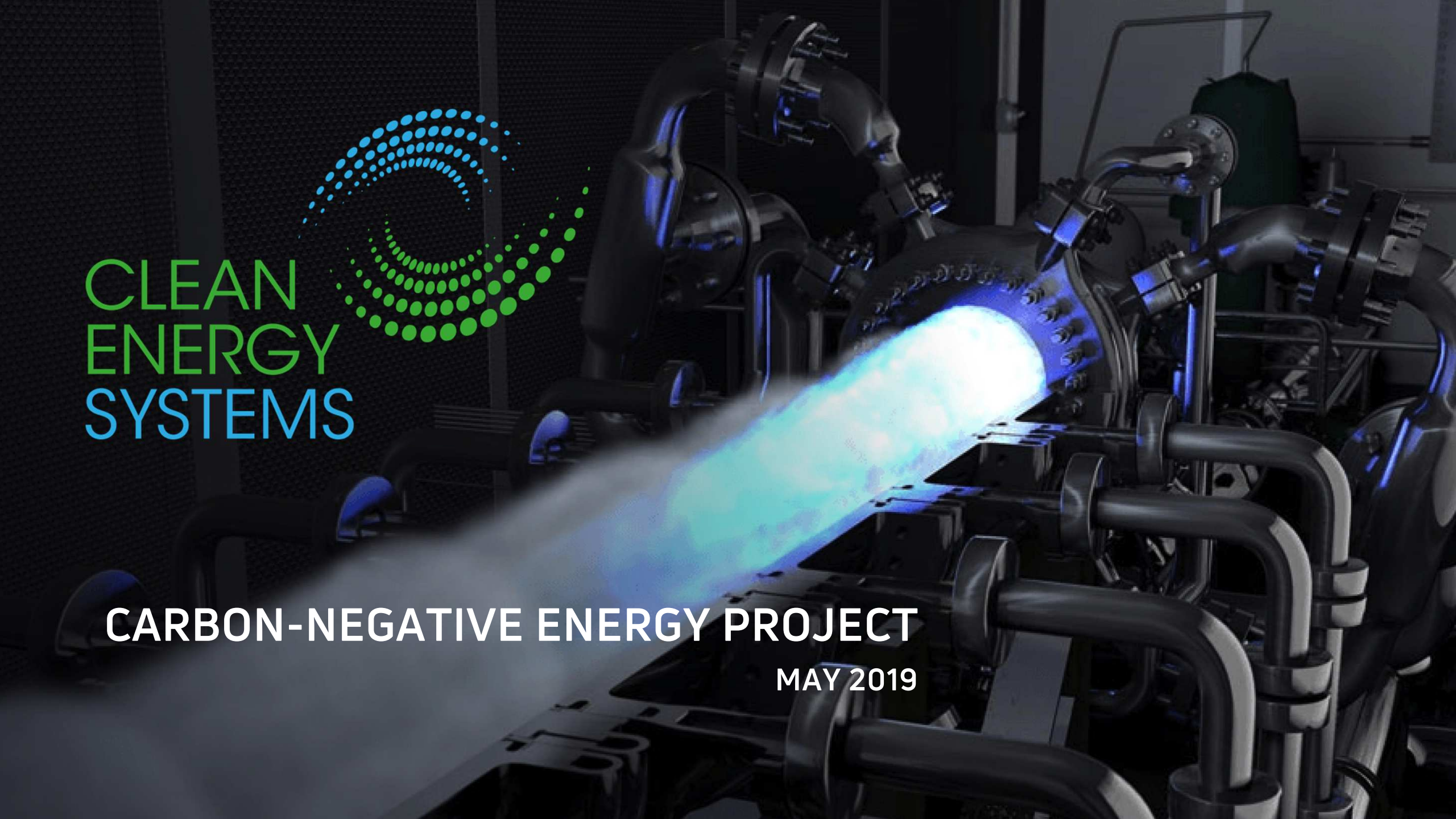


CLEAN ENERGY SYSTEMS

CARBON-NEGATIVE ENERGY PROJECT

MAY 2019

OUR VISION

CLEAN ENERGY SYSTEMS

Clean Energy Systems is the global leader in the development and deployment of Carbon-Negative Energy (CNE) and Carbon Reduction Solutions (CRS)

The Power to Reverse Climate Change

CES | SOLUTIONS

CLEAN ENERGY SYSTEMS

Carbon-Negative Energy (CNE)

Removes existing carbon (CO_2) from the atmosphere and produces power

CES seeks to build a portfolio of carbon negative energy (CNE) plants in California

California offers a unique combination of opportunities to deploy CNE

1. Enormous potential for onshore carbon storage
2. Excess of biomass wastes and idled resources
3. Robust carbon pricing and trading network
4. Strong government support and commitment to low carbon future
5. Process produces valuable water in drought prone agricultural zone

Carbon Reduction Solutions (CRS)

Reduces the amount of carbon released to the atmosphere from existing industrial processes

This is accomplished by:

Clean steam generation

Heat exchange solutions to enable efficient renewable energy and clean power production

Zero-emissions power production

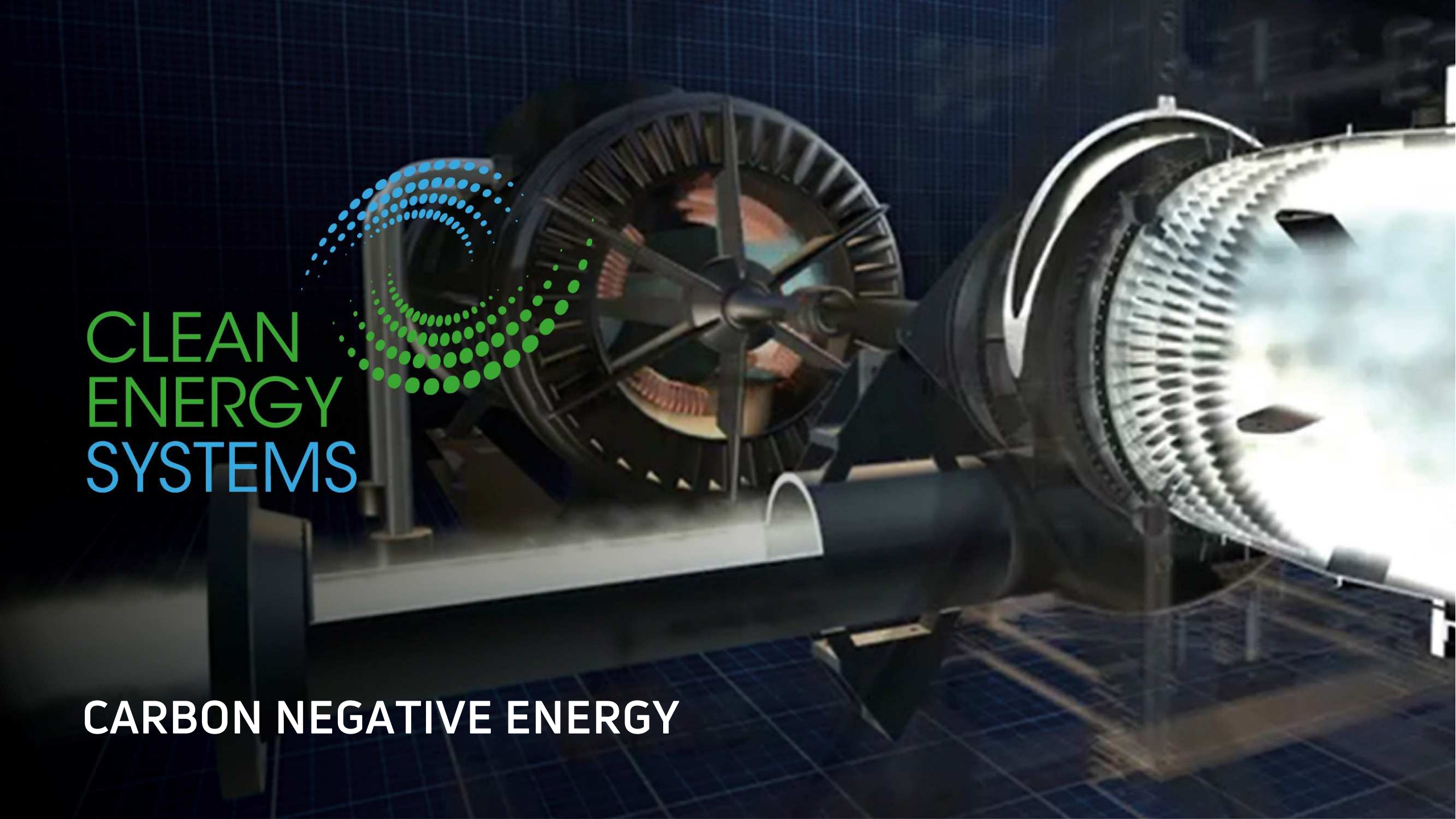
Energy storage solutions

In addition, CES offers engineering services and legacy aerospace work to drive technology advancements that can be incorporated into its products

CES | COMPANY BACKGROUND & OVERVIEW

CLEAN ENERGY SYSTEMS

- Founded in 1993 by former Aerojet (a GenCorp company) aerospace engineers; incorporated in 1996, Clean Energy Systems, Inc. (CES)
- Multiple locations in California:
  - Corporate Engineering and Headquarters, Rancho Cordova (Sacramento Area)
  - Kimberlina Test Facility (former 5 MWe Biomass Power Plant), Bakersfield
  - Placerita Power Plant (former 120 MWe CHP Plant), Santa Clarita
- 30 patents issued on zero-emissions oxy-combustion technology power cycles (36 pending)
- Focused on developing and deploying enabling technologies for advanced clean energy
  - Oxy-Fuel (O-F) Pressurized Direct and Indirect Steam Gas Generators and Reheat Combustors
  - Compact Diffusion Bonded Heat Exchangers
  - O-F Turbines (OFTs) with development partners


CLEAN
ENERGY
SYSTEMS
CARBON NEGATIVE ENERGY

CES CNE | HOW IT WORKS

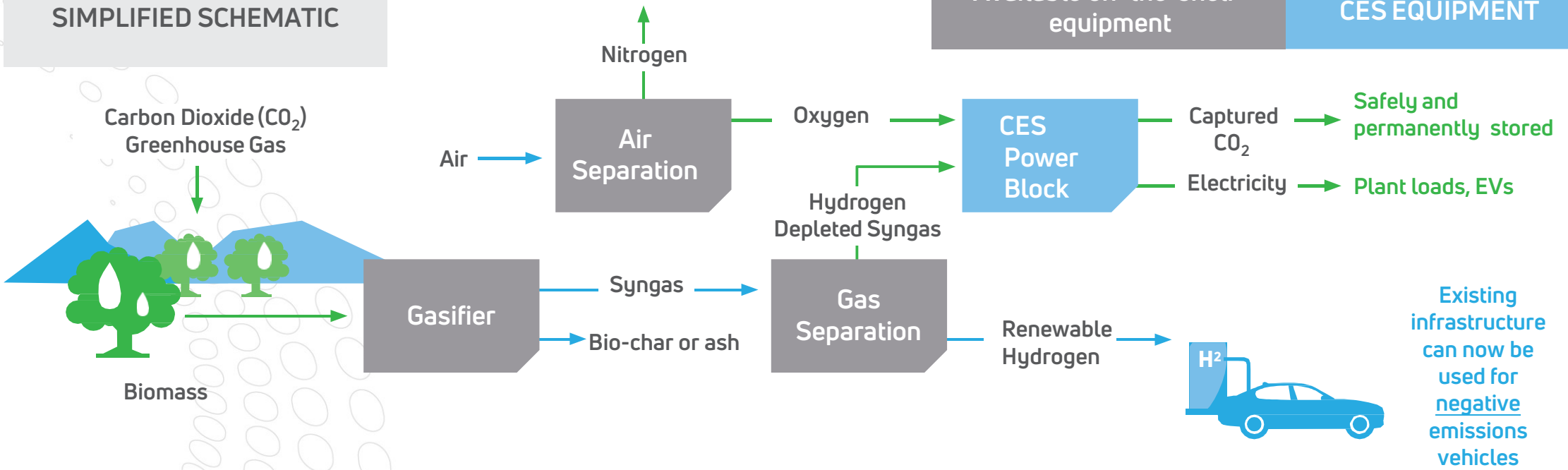
CLEAN ENERGY SYSTEMS

CNE plants use waste biomass feedstocks, which have consumed carbon in the form of CO_2 during their lifetime, to produce syngas from which renewable hydrogen (RH_2) is separated for sale to the transportation sector. The remaining (hydrogen-depleted) fuel is combusted using CES' oxy-fuel technology to produce power with full carbon capture, effectively removing CO_2 from the atmosphere. 1 tonne biomass = ~18 kg RH_2

SIMPLIFIED SCHEMATIC

Available off-the-shelf equipment

CES EQUIPMENT

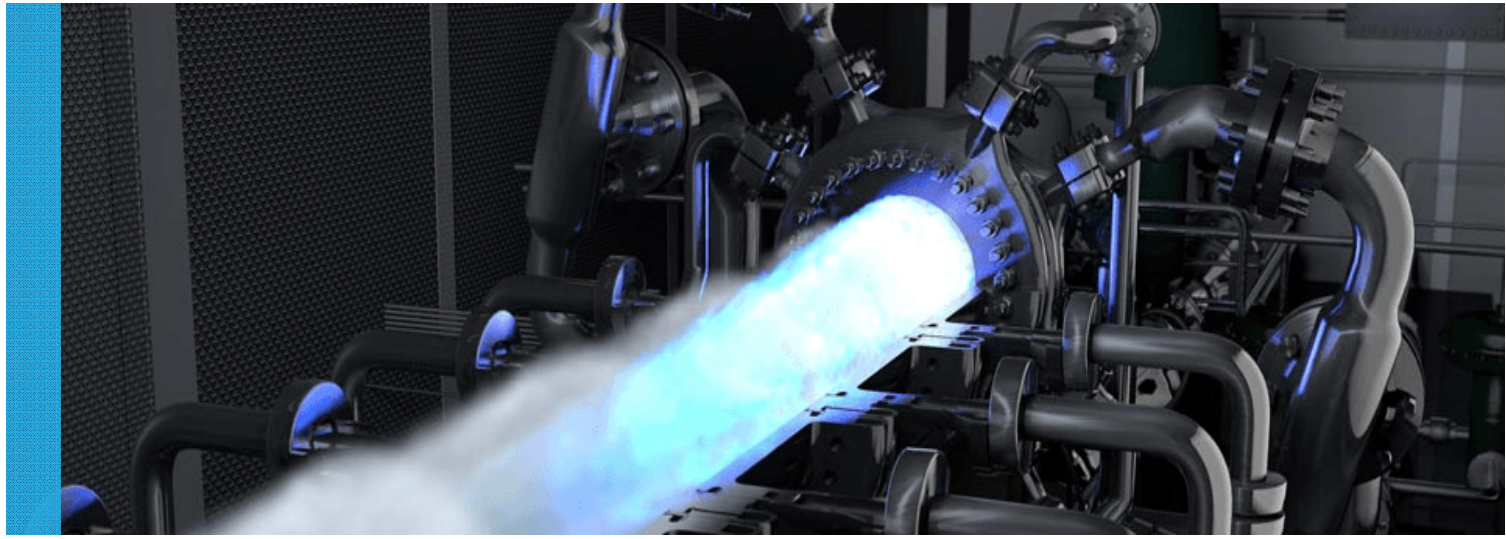


CES ENABLING TECHNOLGY | PRESSURIZED OXY-COMBUSTION

CLEAN ENERGY SYSTEMS

Derived from the American space program, CES combustion systems burn nearly pure oxygen (in lieu of air) with gaseous fuels such as natural gas, associated/field gas, syngas, high-CO_2 content natural gas, or even liquid fuels, for a cleaner, more efficient combustion process

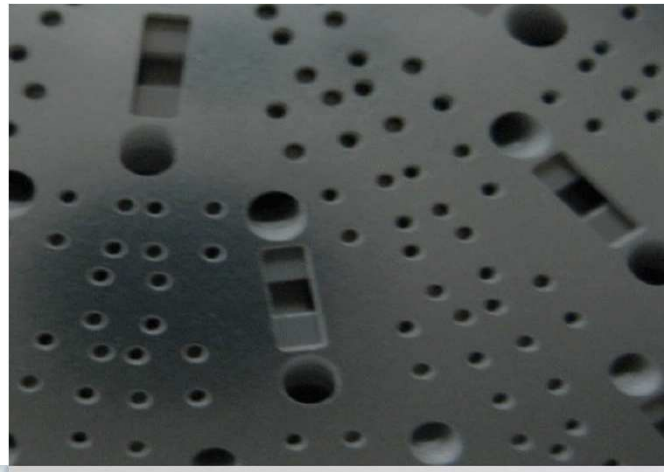
The intimate mixing of gases via unique IP allows for complete combustion generating only water (in the form of high-pressure steam) and CO_2 as the products of combustion. The steam may be used for industrial processes while the CO_2 is easily separated and captured for industrial use or permanent storage.

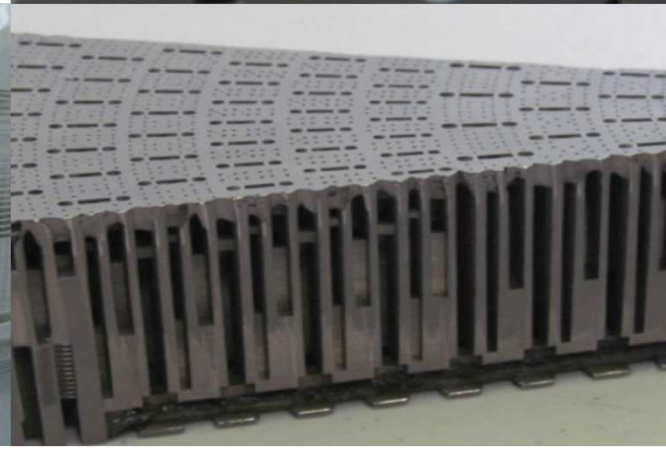


CES ENABLING TECHNOLGY | PLATELETS

CLEAN ENERGY SYSTEMS

- **Precise, stoichiometric combustion** enabled by proven, reliable, platelet injectors
- **Hundreds of individual platelets** are designed and photo-etched to created unique, intricate patterns
- **Platelets are stacked** in a set pattern to form 3D internal flow passages not possible via any other process
- **Platelet stack is then bonded into a single monolithic structure** that can then be machined and assembled
- **The resultant intricate individual pathways** channel fuel, oxygen, and water to hundreds of combustion elements, where intimate stoichiometric mixing occurs, resulting in complete combustion





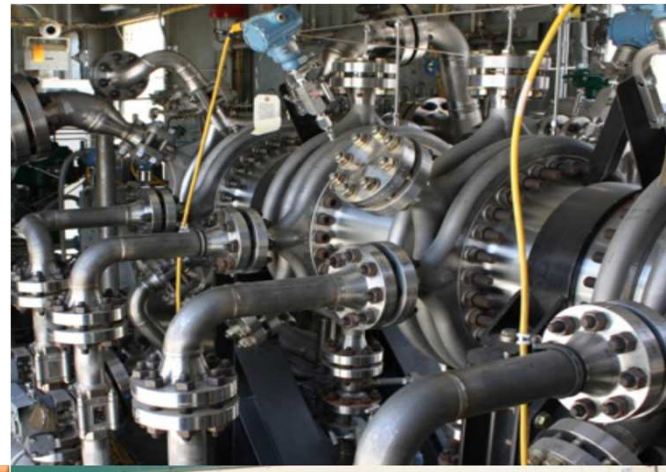
CES | DIRECT STEAM GAS GENERATORS

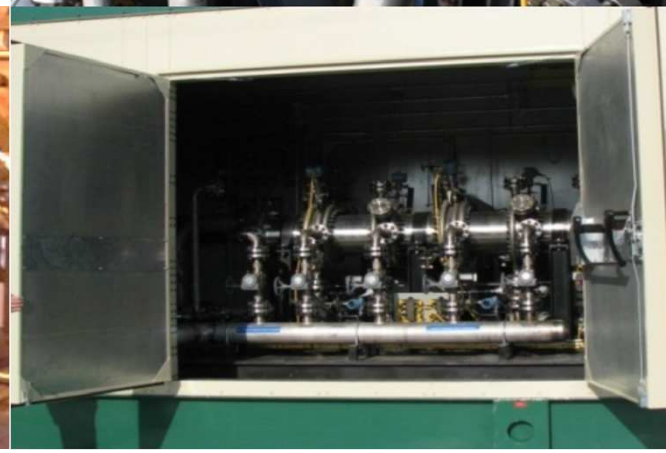
CLEAN ENERGY SYSTEMS

Compact system produces only steam and high-purity CO_2, along with massive amounts of thermal energy

- Current designs with 10 cm (4-inch) or 30 cm (12-inch) internal diameters
- Range from 10 to 200 MWt delivering temperatures up to 1,650 °C (3,000 °F) and capable of pressures over 110 bar (1,600 psi)

- Water injection and jacket cooling incorporated for long life
- Standalone installation includes control and monitoring system
- Ramps to full power in seconds





CES | DIRECT STEAM GAS GENERATOR PACKAGE

CLEAN ENERGY SYSTEMS

Fully containerized oxy-combustion system for easy transport and installation

- **Combustor:** 2 meters (6 feet) long with 30 cm (12 inch) internal diameter
- **Container:** 3.3 meters (11 feet) x 3.3 meters (11 feet) x 12 meters (40 feet)
- Capable of transport via standard shipping vehicles
- Designed and built to ASME Section VIII, Div. 1
- Fully automated fire detection and suppression system
- Includes video monitoring and surveillance
- Minimized install time and cost

CES | OXY-FUEL TURBINES

CLEAN ENERGY SYSTEMS

With development partners, turbines designed for high-quality steam and high CO_2-content drive gas

- Currently two turbines retrofit
- Removed front-end compressor section and replaced with thrust balance system
- Modified for pressurized steam-CO_2 gas
- Operate at gas turbine conditions

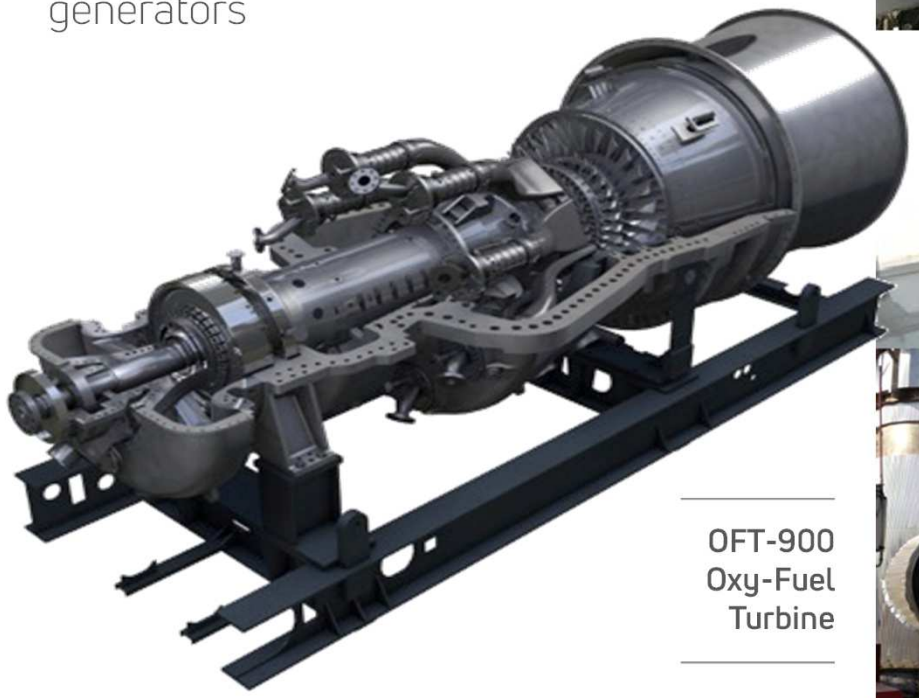
GE J79 retrofit to OFT-J79

- Up to 43 MWe from 12 MWe baseline

SGT-900 (W251 B12) retrofit to OFT-900

- Up to 150 MWe from 43 MWe baseline
- Makes use of CES reheat combustors
- CES, FTT, and Siemens design

Future turbine potential for new designs matching temperature/pressure profile of CES direct steam gas generators



OFT-900 Oxy-Fuel Turbine

With development partners

OFT-J79 Oxy-Fuel Turbine

CES | COMPACT HEAT EXCHANGERS

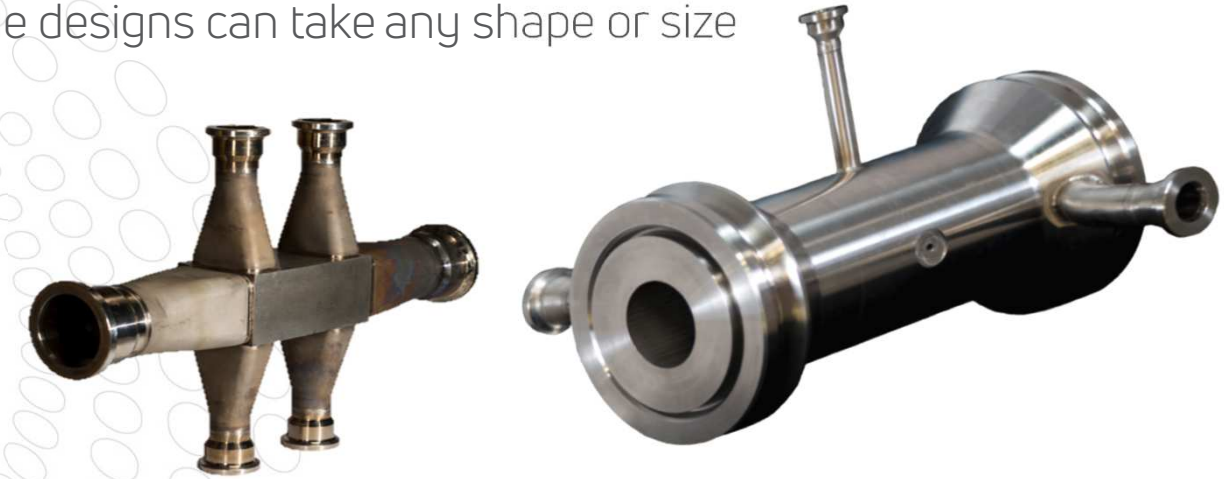
CLEAN ENERGY SYSTEMS

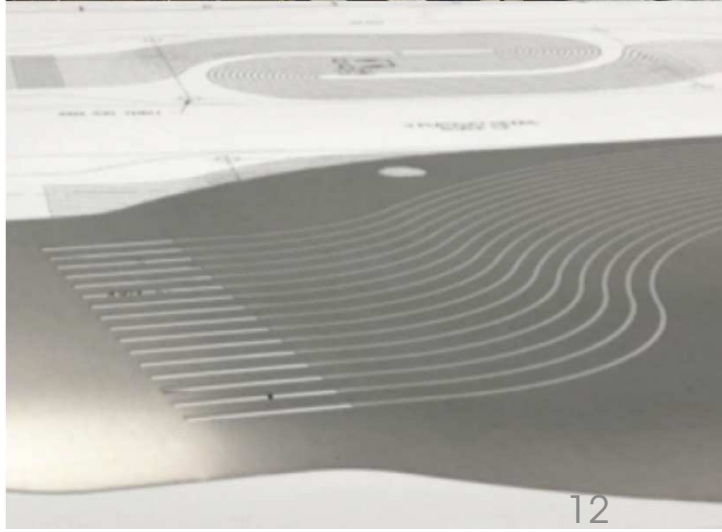
HEXCES

COMPACT PLATELET HEAT EXCHANGERS (CPHX)

Diffusion bonded heat exchangers enable thermal energy storage (concentrating solar power) and next generation energy systems

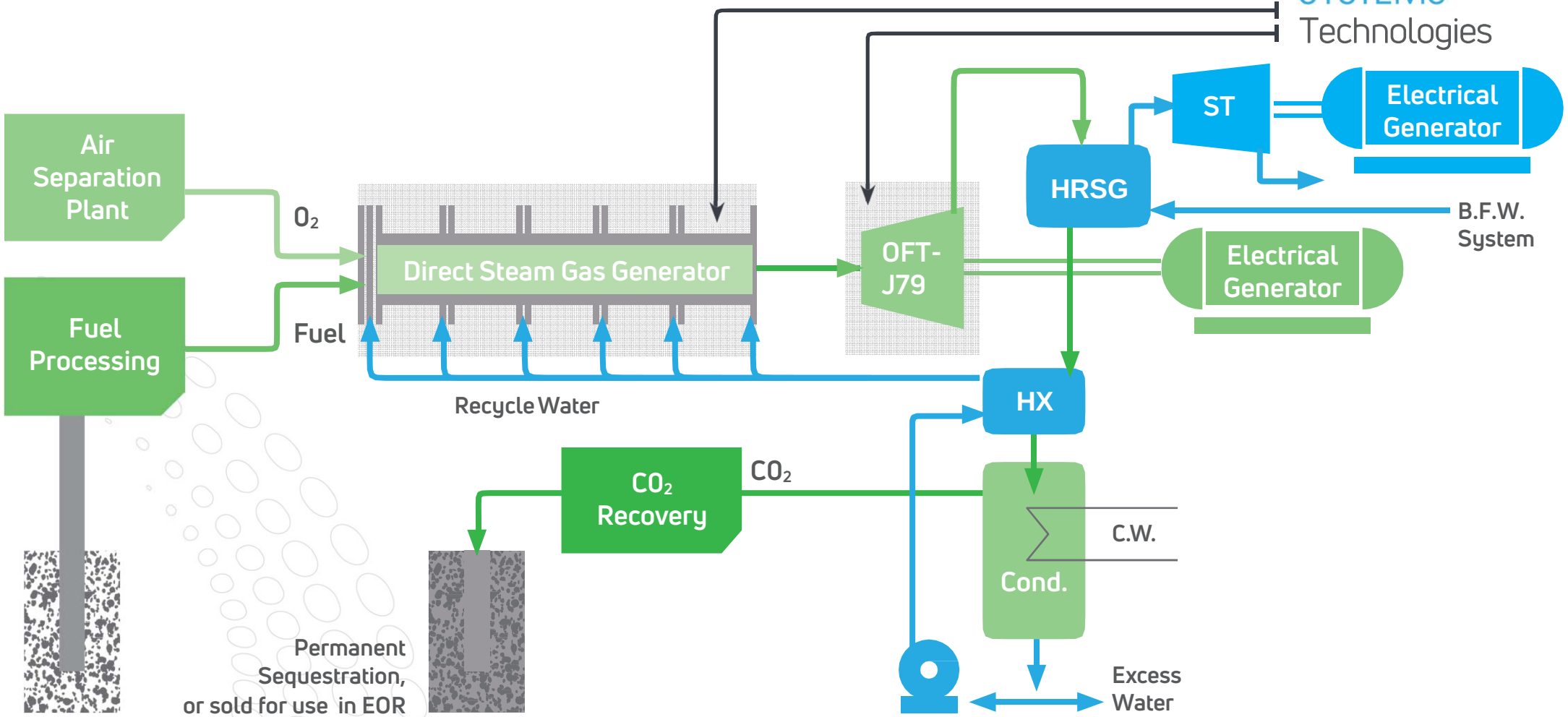
- Capable of handling extreme operating temperatures and pressures (-200 to 900 °C, 600+ bar)
- 4 to 6 times smaller and lighter than conventional exchangers
- Unparalleled thermal effectiveness
- Unique designs can take any shape or size





CES | POWER BLOCK

CLEAN ENERGY SYSTEMS Technologies



CNE | PROJECT OVERVIEW

CLEAN ENERGY SYSTEMS

Kimberlina Power Plant

Base Case CNE Plant

- 300 TPD biomass feedstock
- Roughly 5,400 kg/day renewable hydrogen
  - Transported to off-taker via truck; pipeline injection in the future?
  - Enough to fuel ~ 1,000 FCEVs
- Captures and permanently stores approx. 485 tonne/day of CO_2
  - Equivalent to removing over 31,500 passenger vehicles from the roads annually, or approx. 3 lbs. CO_2 removed per mile driven
- Plant loads covered by onsite generation with full carbon capture
- Repeatable and scalable

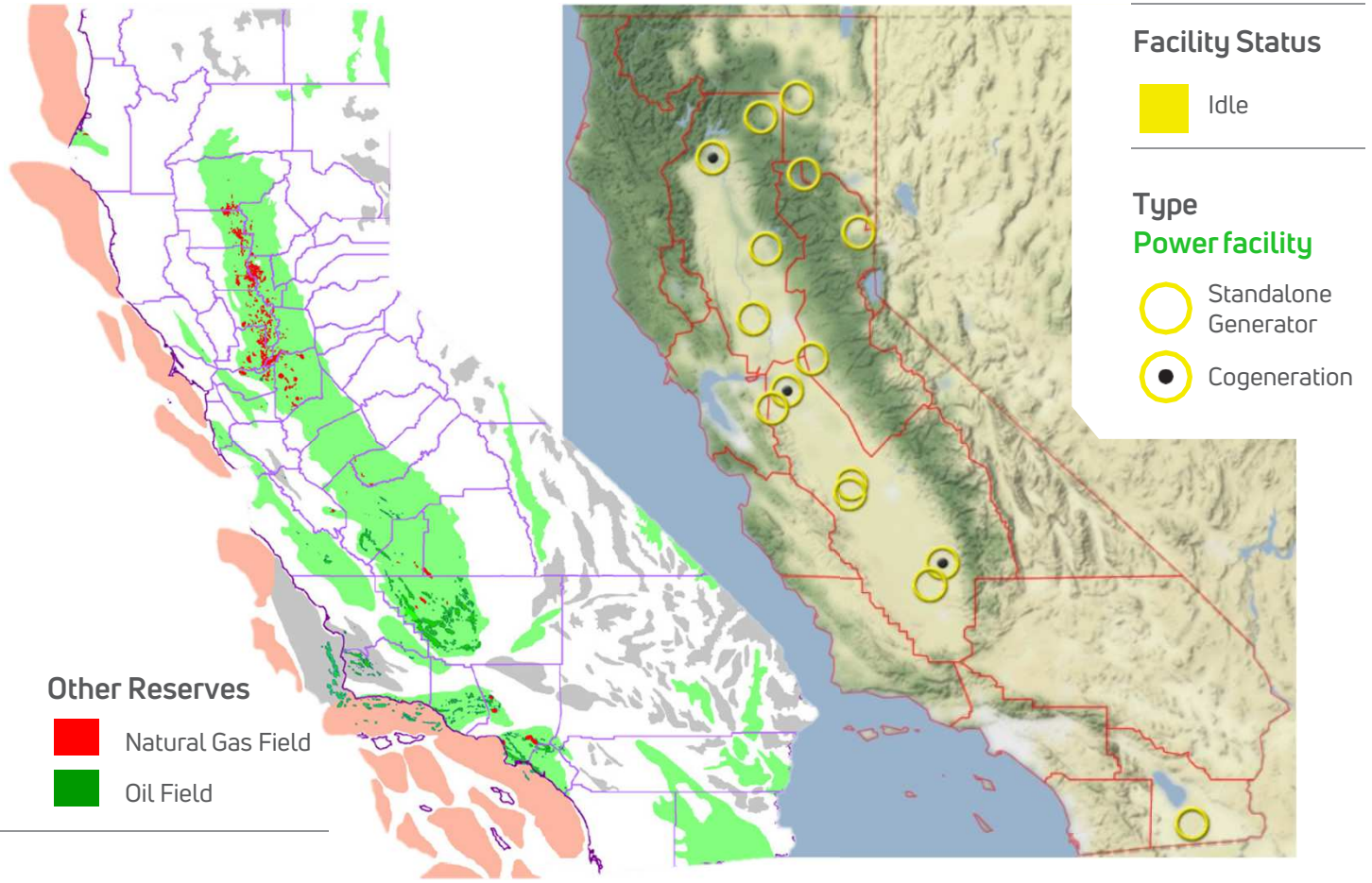
CNE Plant Options

- Ability to produce renewable natural gas (RNG) and/or electricity for export in place of, or in addition to, renewable H_2
  - RNG: 3,200 MM BTU/day
    - Reduces the total amount of CO_2 captured and stored – not captured from tailpipes
  - Power: 6 MWe (net)
    - Same ~485 tonne/day CO_2 captured
    - Use in EVs removes approx. 3 lbs. CO_2 per mile driven

CNE | FUTURE POTENTIAL PROJECTS IN CALIFORNIA

CLEAN ENERGY SYSTEMS

- A comparison of idle biomass facilities to California's sedimentary basins shows excellent potential for carbon capture and storage and possible use in enhanced oil or gas recovery (EOR/EGR)
- At least 15 idle biomass power plants in California today, with more anticipated to close in the coming years



Map Courtesy of WESTCARB

CNE | SUMMARY & NEXT STEPS

CLEAN ENERGY SYSTEMS

- CES' CNE plants have the potential to generate renewable power and other fuels while effectively removing millions of tons of CO_2 from the atmosphere
  - The time is now to deploy – valuable carbon market, idled resources, abundance of feedstock
  - Plants can be scaled and configured to optimize specific site characteristics and market demand
- CES plans to develop a portfolio of CNE plants across California, making use of currently idled biomass facilities, revitalizing valuable assets and improving the state's air quality
- CES performing project development for the first CNE plant
  - Likely to be located at our Kimberlina facility in Bakersfield
  - Primary focus is developing CCS component as it comes with the greatest number of unknowns
- Future projects will ideally inject RH_2 directly into pipeline
  - "Virtual" transportation identical to allowance for biomethane
  - Helps decarbonize all processes using RNG
  - Requires protocol for injection

Thank You!

For more information contact:

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